A Review of North Atlantic Ocean Modeling in an Eddying Regime

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The Climate, Ocean, and Sea Ice Modeling project (COSIM) [1] began as an effort to bring ocean general circulation modeling to massively parallel computers, and quickly expanded to include applications. The second large application undertaken by the project was a high-resolution simulation of the North Atlantic Ocean. Initiated in 1996 (before the advent of the moniker COSIM), the effort led to publication of a paper [2], which is now seen as marking the advent of the era of ocean modeling in a strongly eddying regime.

Eddies within the ocean are the analog to storm systems in the atmosphere. Their sizes are determined by wave propagation speeds and the rotational period of the Earth. The slower speed of the relevant waves in the ocean makes for a much smaller size than that found in the atmosphere, and tremendously high spatial resolution is therefore required in order to adequately resolve oceanic eddies. The importance of the eddies lies not only in the mixing of water properties, but in their feedback on the large-scale, time-mean circulation of the oceans.

A decade ago the weak level and inadequate influence of eddy variability on mean circulation was most prominently illustrated by the poor representation of the North Atlantic's Gulf Stream. The simulation presented in [2], performed on the Connection Machine, CM-5, in what was then known as LANL's Advanced Computing Laboratory, not only achieved a level of eddy variability that compared favorably with that inferred from satellite-borne instruments, but also produced a greatly improved representation of the Gulf Stream (Fig. 1).

North Atlantic Ocean modeling has continued to be an active focus for the Laboratory's COSIM project, with research focused both on physical understanding and on the more empirical problem of how to best configure a model for the "grand challenge-scale" problem of global ocean modeling in a strongly eddying regime.

The progress of this past decade is discussed in a review paper [3], to appear early in 2008. One point emphasized in the review is the importance of eddies in invigorating the deep circulation (Fig. 2). This deep circulation in turn interacts with the more readily observed currents of the upper ocean.

The North Atlantic Ocean is also of central interest to the Earth's climate. New work is underway to determine the importance of a more accurate and realistic circulation to the stability of modeled climate.

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[1] http://climate.lanl.gov/COSIMHistory.pdf
[2] R. Smith et al., *J. of Physical Oceanography*, **30,** 1532-1561 (2000).
[3] M. Hecht and R. Smith, in *Ocean Modeling in an Eddying Regime,* American Geophysical Union Geophysical Monograph Series, Hecht and Hasumi, Eds. (2008).

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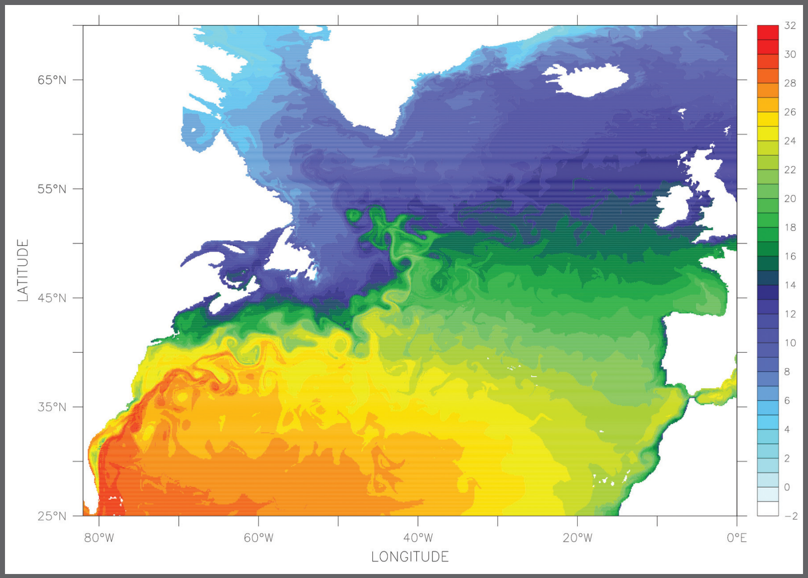

Fig. 1. Sea surface temperature in the Gulf Stream region of the North Atlantic Ocean, from a simulation at the relatively high horizontal grid resolution of 0.1 degree.

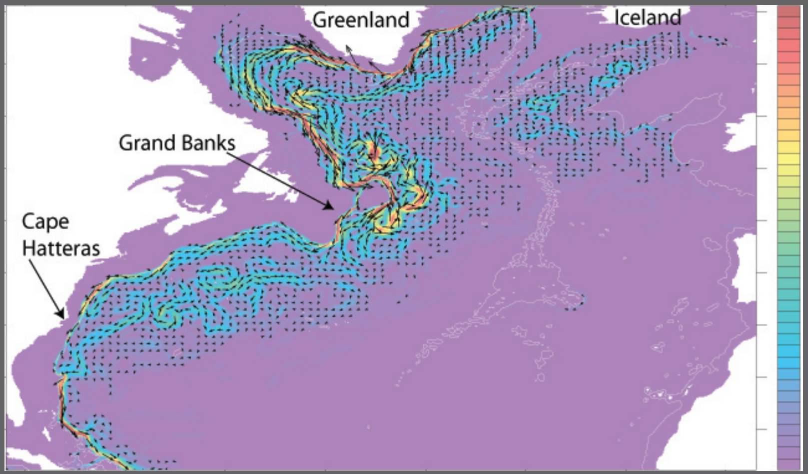

Fig. 2. Deep ocean transport from the same simulation as in Fig. 1. Total volume transport of cold, deep waters with potential temperatures between 3 and 4 degrees Celsius is shown, with transport vectors superimposed. This vigorous deep circulation is now known to be one of the elements required in order to establish the correct upper ocean circulation of Fig. 1.